

CLAIMS

1. A gallium nitride-based compound semiconductor light-emitting device comprising an n-type semiconductor layer of a gallium nitride-based compound semiconductor, a light-emitting layer of a gallium nitride-based compound semiconductor and a p-type semiconductor layer of a gallium nitride-based compound semiconductor formed on a substrate in this order, and having a negative electrode and a positive electrode provided on the n-type semiconductor layer and the p-type semiconductor layer, respectively; wherein the negative electrode comprises a bonding pad layer and a contact metal layer which is in contact with the n-type semiconductor layer, and the contact metal layer is composed of Cr or a Cr alloy and formed through sputtering.

2. A gallium nitride-based compound semiconductor light-emitting device according to claim 1, wherein the Cr alloy includes Cr and a metallic element having a work function of 4.5 eV or less.

3. A gallium nitride-based compound semiconductor light-emitting device according to claim 2, wherein the metallic element having a work function of 4.5 eV or less is at least one metallic element selected from the group consisting of Al, Ti, Si, Mn, Fe, Co, Ni, Cu, Zr, Nb, Mo, Hf, Ta, W, and V.

4. A gallium nitride-based compound semiconductor light-emitting device according to claim 3, wherein the metallic element having a work function of 4.5 eV or less is at least one metallic element selected from the group consisting of Al, V, Nb, Mo, W, and Mn.

5. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 4, wherein the Cr alloy has a Cr content of 1 mass% or more and less than 100 mass%.

6. A gallium nitride-based compound semiconductor light-emitting device according to claim 5, wherein the Cr alloy has a Cr content of 10 mass% or more.

7. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 6, wherein the contact metal layer has a thickness of 1 to 500 nm.

5        8. A gallium nitride-based compound semiconductor light-emitting device according to claim 7, wherein the contact metal layer has a thickness of 10 nm or more.

10       9. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 8, wherein the bonding pad layer is formed of a metal selected from the group consisting of Au, Al, Ni, and Cu, or an alloy containing the metal.

15       10. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 9, wherein the bonding pad layer has a thickness of 100 to 1,000 nm.

20       11. A gallium nitride-based compound semiconductor light-emitting device according to claim 10, wherein the bonding pad layer has a thickness of 200 to 500 nm.

25       12. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 11, wherein an Au-Sn alloy layer is provided on the bonding pad layer.

30       13. A gallium nitride-based compound semiconductor light-emitting device according to claim 12, wherein the Au-Sn alloy layer has a thickness of 200 nm or more.

35       14. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 11, wherein a lead free solder layer is provided on the bonding pad layer.

      15. A gallium nitride-based compound semiconductor light-emitting device according to claim 14, wherein the lead free solder layer has a thickness of 200 nm or more.

      16. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 15, wherein the light-emitting device has an adhesion layer formed of Ti between the contact metal layer and

the bonding pad layer.

17. A gallium nitride-based compound semiconductor light-emitting device according to claim 16, wherein the adhesion layer has a thickness of 1 to 100 nm.

5 18. A gallium nitride-based compound semiconductor light-emitting device according to claim 17, wherein the adhesion layer has a thickness of 10 nm or more.

10 19. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to 15, wherein the light-emitting device has a barrier layer between the contact metal layer and the bonding pad layer.

15 20. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 12 to 18, wherein the light-emitting device has a barrier layer between the bonding pad layer and the Au-Sn alloy layer or the lead free solder layer.

20 21. A gallium nitride-based compound semiconductor light-emitting device according to claim 19 or 20, wherein the barrier layer is formed of a metal selected from the group consisting of Ti, Zr, Hf, Ta, W, Re, Os, Ir, Pt, Fe, Co, Ni, Ru, Rh, and Pd, or an alloy containing the metal.

25 22. A gallium nitride-based compound semiconductor light-emitting device according to claim 21, wherein the barrier layer is formed of a metal selected from the group consisting of Ti, Ta, W, and Pt, or an alloy containing the metal.

30 23. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 19 to 22, wherein the barrier layer has a thickness of 10 to 500 nm.

35 24. A gallium nitride-based compound semiconductor light-emitting device according to claim 23, wherein the barrier layer has a thickness of 50 to 300 nm.

25. A gallium nitride-based compound semiconductor light-emitting device according to any one of claims 1 to

24, wherein the light-emitting device is of a flip-chip type.

5        26. A negative electrode for use in a gallium nitride-based compound semiconductor light-emitting device comprising a bonding pad layer and a contact metal layer which is in contact with the n-type semiconductor layer, wherein the contact metal layer is composed of Cr or a Cr alloy and formed through sputtering.

10       27. A negative electrode for use in a gallium nitride-based compound semiconductor light-emitting device according to claim 26, wherein the light-emitting device is of a flip-chip type.

15       28. A method for manufacturing a gallium nitride-based compound semiconductor light-emitting device comprising

20           (a) forming an n-type semiconductor layer of a gallium nitride-based compound semiconductor, a light-emitting layer of a gallium nitride-based compound semiconductor and a p-type semiconductor layer of a gallium nitride-based compound semiconductor on a substrate in this order,

25           (b) providing a positive electrode and a negative electrode, which comprises a bonding pad layer and a contact metal layer, on the p-type semiconductor layer and the n-type semiconductor layer, respectively;

             wherein the contact metal layer is forming through sputtering Cr or a Cr alloy on the n-type semiconductor layer to attain Ohmic contact without performing annealing.

30       29. A lamp comprising a gallium nitride compound semiconductor light-emitting device according to any one of claims 1 to 25.